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## ADHD in eHealth - A Systematic Literature Review

Morten Rismo Olsen <sup>a</sup>, Cristina Casado-Lumbreras <sup>b</sup>, Ricardo Colomo-Palacios <sup>a\*</sup>

<sup>a</sup>*Østfold University College, B R A Veien 4, Halden 1783, Norway*

<sup>b</sup>*Universidad Complutense de Madrid, Campus de Somosaguas. 28223 - Pozuelo de Alarcón MADRID, Spain*

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### Abstract

The healthcare industry is facing financial, and population pressures relating to cost, access quality, accountability, and the integration of information and communication technology (ICT). eHealth has been referred to as possibly the most important revolution in healthcare since the arrival of modern medicine. The purpose of this study is to outline recent development in applying eHealth in the healthcare industry, focusing on the therapy of patients with Attention Deficit Hyperactivity Disorder (ADHD) in recent years. A systematic review was conducted to explore reported therapy practices for patients with ADHD using eHealth technologies. Results indicates efficacy of telemedicine therapy suggesting an improvement in quality of therapy. Further the emergence of mobile health (mHealth) solutions seems to be a central topic, thus there is need for empirical studies to support such utilities. Electronic health records (EHRs) are facing legislative constrains before fully exploiting its full potential that gives promise for both increased efficiency and cost savings.

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### 1. Introduction

Ontario Hospital eHealth Council defines eHealth as follows:” eHealth is a consumer centered model of healthcare where stakeholders collaborate utilizing information and communication technologies including Internet technologies

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\* Corresponding author. Tel.: + 47 6921 5000; fax: + 47 6921 5002..

E-mail address: [ricardo.colomo-palacios@hiiof.no](mailto:ricardo.colomo-palacios@hiiof.no)

to manage health, arrange, deliver, and account for care, and manage the healthcare system” [1]. With the birth of the Internet, there was an emergence of e-terms in the middle and late 1900s. Among these was the term eHealth. According to Faber [2], it was John Mitchell who coined the term eHealth back in 1999 [3]. eHealth has become an umbrella term covering telehealth and health informatics (HI), facilitating care locally and from a distance. A more widely used definition is that of the World Health Organization (WHO) being: “The cost effective and secure use of information and communication technologies for health and health-related purposes” [4]. A study in 2010 [5] found, among 45 others, a definition stating: “Interactive applications, services, and tools that are web-based services for healthcare consumers, caregivers, patients, and health professionals”. The terms are being used interchangeably, thus an overview of what these terms presently encompass is: EHRs, clinical decision support, telemedicine, consumer health informatics, health knowledge management, mHealth and health informatics/healthcare information systems.

In recent years, health reforms have prevailed in several countries. One example is the Health Information Technology for Economic and Clinical Health Act (HITECH) of 2009 [6] offering incentives for adopting EHR technology in order to increase efficiency in hospitals in the United States. Another indication of the adoption of EHR was proclaimed by the Norwegian government in 2012 by stating in white Paper no.9: “One citizen, one record” [7]. The date of the aforementioned shows that governments in these countries have just recently introduced EHR technologies. The needs of patients turning to health professionals, depends on many factors. Even though patients are treated according to diagnosis, there are factors that apply to the individual patient in question. International Alliance of Patients’ Organizations applies a principle for patient-centered healthcare as follows: “Respect and support for the individual patient according to their rights, wants, preferences, values and needs” [8].

ADHD is characterized by pervasive and impairing symptoms of inattention, hyperactivity, and impulsivity [9]. Patients with ADHD are at high risk of suffering from comorbidities such as anxiety and depression [10], which requires therapy than ADHD diagnosed patients who suffer from substance abuse, which is another pattern in adolescents and adults with untreated ADHD [11]. ADHD is a neurodevelopmental disorder with onset in childhood and early adolescence [11]. Moffitt et al. [12] argue that there are distinct differences in the need of children with ADHD and adults as the onset and development of this disorder shows indications that childhood ADHD is connected to hyperactivity while difficulties attaining attention is more prevalent in adult ADHD. Recent study provides valuable feedback on the needs of ADHD patients experience from the point of consulting a healthcare professional, until appropriate therapy commences. A recent study [13] shows that the use of remote monitoring technology (RMT) can be found beneficial in following patients after initializing a therapy program such as psychotherapeutic and psychopharmacologic intervention. In the study [13], patients in a test group reported that: “For example, while access to diagnosis was identified as the most significant unmet need, participants’ aspirations for technological support focused on therapy and support”. This provides cause for further investigation, given that there is a common misconception has been that ADHD is a childhood affliction. Moreover, studies on ADHD were, according to Barkley [14], made popular in 1994 when Hallowell et al. [15] pointed out that the existence of ADHD in adults in literature, dates back at least to the 1960s.

The driving force for this study is to present reported therapy methods that are being offered to patients with ADHD from a technological point of view. The focus on what eHealth technologies can serve this, although diverse, group of patients will be presented in this paper. A systematic literature review was initiated to outline current practices in treating patients with ADHD with focus on the technological aspect. Section 2 presents the methodology used for this purpose. Section 3 presents the results and discusses the study in addition to answering the research questions (RQs). Section 4 points to limitations of this study. In section 5 final thoughts and a proposition for future work is outlined.

## 2. Research methodology

The aim of this paper is to outline the outcome of eHealth progress and how patients, using ADHD as a case, can benefit from this technology. The scope includes reported therapy methods and practices where the implementation of eHealth, e.g. telemedicine, RMT and mHealth devices used for mental health promoting purposes, has aided or improved the quality of therapy. Thus the propulsive RQ for this study is:

- What are the reported therapy practices using eHealth technologies for patients with ADHD?

Considering the nature of this topic, a systematic literature review was conducted in reference to guidelines used by Jones et al. [16] in a systematic literature review with a health information technology perspective. The

methodology is heavily influenced by Chaudhry et al. [17], Goldzweig et al. [18] and Buntin et al. [19]. In the sections that follow, the RQs are described and the correlating metrics for the study are presented.

### 2.1. Research questions

To ensure that the scope is being investigated according to the aforementioned aim, the author of this paper produced several RQs which will be answered in section 3. The RQs are defined as follows:

- RQ1 - What are the reported eHealth-aided forms of therapy being offered to patients with ADHD?
- RQ2 - What is the contribution of eHealth technologies to ADHD patients?
- RQ3 - To what extent does the vision of eHealth benefits serve people with ADHD?

### 2.2. Search strategy

The review included four of the most popular academic digital libraries in the field of information systems. It is important to note that authors used the most common databases from the information systems point of view (POV), assuming the bias of not using purely medical databases or even hybrid ones and thus, taking out important sources like Journal of Medical Internet Research, for instance, more information is available in the limitations section:

- ACM Digital Library (<http://dl.acm.org>)
- IEEEExplore Digital Library (<http://ieeexplore.ieee.org>)
- Science Direct (<http://www.sciencedirect.com>)
- Springer Link (<http://link.springer.com>)

In order to attain hits relevant to the scope, the author used the main areas of eHealth technologies in the search string. This was tuned by searching the chosen libraries in Google Scholar's search engine, found at (<http://scholar.google.com/>). This test resulted in the following search string, which was to be used in the library search: ("ADHD" OR "attention deficit hyperactivity disorder") AND "therapy" AND ("eHealth" OR "medical informatics" OR "telemedicine" OR "electronic health records" OR "clinical decision support" OR "consumer health informatics").

### 2.3. Study selection

The study was based on recent research/reported practices in the field. Another criterion was that the papers were to be free of charge, meaning either being available for free by using an Østfold University College account, or by having a free-to-use publication showing up in Google Scholar. As a means of avoiding researcher bias, the author outlined the following exclusion criteria:

- Based of accessibility - Libraries that accessible in Østfold University College.
- Based on publication date - Papers published before 2010.
- Based on language - Papers not written in English.
- Based on title - The title does not imply relation information technology.
- Based on abstract - The abstract does not describe eHealth technologies.
- Based on full text - The content is not relevant to the RQs.

### 2.4. Study classification

In the study classification, the papers that were selected in the initial phase were group according to keywords gathered from the individual papers. Keeping the RQs in mind, the papers were classified according to the phrases used in the search string. This consequently resulted in 2 categories:

- Telemedicine - Papers that present remote-enabled therapy.
- Electronic Health Records - Papers that present practices of patient-related information exchange between healthcare professionals.

To promote papers that focus on therapy of ADHD patients more than the means of achieving this, one category was chosen for papers presenting a combination of these three.

## 2.5. Study extraction

Using a reference manager, the full text extracted papers were gathered. The distribution of publication dates shows that 2015 is represented the most with a total of 9 papers. Apart from that, there are no papers from 2014, 2012 nor 2010 among the selected papers. The initial results of the IEEE library search returned over 6000 papers whereas only the 200 first papers were evaluated.

## 3. Analysis and discussion of results

Included and excluded studies have been put through the filtering process as described above. Given that the search string is presented, and the exclusion criteria were established, the papers can be found using the same methodology. The results from the search are presented in the table below (table 1). During the filtering process, including categorizing the papers according to title, abstract and grouping them by keywords, the author singled out 46 papers for full-text extraction. This resulted in 10 papers to base the review. The following section presents answers to the RQs based on the literature used in the study (see table 1). In addition, the following sections **RQ1** include a discussion that will function as a test to what degree the found material satisfies the objective of the study.

Table 1. Main characteristics of the studies included in this review.

Study	Technology	Outcome measures	Comment
Pandria et al. (2015) [20]	mHealth: (WHAAM) app	Client-server based application focusing on SMART metrics: specific, measurable, attainable, realistic and timely	Applies to parents, caretakers and teachers. Utility for monitoring and assessing behavior. Potential for psychoeducational usage as well as providing data for psychotherapeutic interventions. Needs empirical evidence.
Ryan et al. (2015) [21]	Telemedicine: web-portal	Case study of web portal with psychoeducational potential. Main features was information for supplementing and thus substituting healthcare professional visits	Results show incoherence in success rate of the product. Implications point to lack of quality of the service.
de Bruin et al. (2015) [22]	Telemedicine: Online applications	Case study of online utility to treat patients with insomnia disorder. Classifies as web portal for psychotherapeutic interventions	Results showed to high success rate in test group measured by given metrics. Applies to special needs as insomnia can be related to ADHD. Needs quantitative analysis.
Myers et al. (2015) [23]	Telemedicine: Telemental health	Case study presenting experimental telemedicine therapy methods in children with ADHD. Trial included 5 assessments spanning a 25-week period.	Authors assessment pointed to above average success rate. Data analysis presented in paper shows mediocre data compared to augmented therapy.
Kemppinen et al. (2013) [24]	EHR/Clinical Decision Support	Reporting paper on success rate of implementing a clinical decision support system at a hospital in Finland. Metrics included improvements in workflow and process standardization.	Results implies evidential benefits for caregivers and organizational purposes.
Baum et al. (2013) [25]	eHealth	Review of current eHealth therapy methods. Forecast of potential benefits gained by implementing eHealth technologies.	Reasoning paper synthesizing scenarios for patients with ADHD.
Silva et al. (2015) [26]	mHealth	Review of mHealth applications in general. Includes references to application for ADHD patients.	Focusing on ‘state of the art’ utilities in mHealth technology. Conclusion points to mHealth as a trending technology as of 2015.

Wu et al. (2011) [27]	EHR	Reporting study on experimental methods for mapping comorbidities in correlation with substance abuse. Using electronic health records features in order to attain quantitative analysis.	Results promotes EHR technology as a powerful utility for conducting empirical research. Applies to legislation obstructions.
Geissbuhler et al. (2013) [28]	EHR	Argumentative study on potential of centralizing EHRs. Points to opportunities such as improved efficiency, security, quality of therapy for different actors.	Suggesting legislation change. Implies evidence based support through research.
Van Allen et al. (2011) [29]	Telemedicine: Telemental health	Literature review focusing on telehealth effects in respects of efficiency and quality of therapy.	Points to potential of telemedicine technology. Arguments supported by research.

### 3.1. RQ1 - What are the reported eHealth-aided forms of therapy being offered to patients with ADHD?

Pandria et al. [20] points to several ICT solutions that focus on access and monitoring behavior in ADHD patients and people that have not yet been diagnosed. The study [32] focuses on mHealth technologies, thus the authors list existing solutions, this being web-portals and user centered software solutions:

- ADHD Therapy Researcher - A web-portal providing access to recent advances on ADHD.
- “You can Handle Them All” - Software solution designed for parents or educators to aid managing inappropriate behaviors in children.
- iBAA Behavioral Assessment App - Developed for psychologists to compile and summarize behavioral information using different observation methods such as frequency, interval, qualitative observations, environmental data and reporting.
- School Psychology Tools - Software solution supporting multiple observation methods.

The common trait of these solutions, being mHealth, are developed for monitoring and data collection purposes, with the exception of the “ADHD Therapy Researcher” utility, which is a web-portal with the aim of educating and offering psychoeducational services. The study goes on to list solutions for access, more specifically; access to diagnosis, with the aim of extend the range of clinical practitioners as an early phase of diagnosis:

- ADHD Test - Online test based on the standard Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V), serving as a diagnostic tool for parents or someone wanting to take the test themselves.
- ADHD Test-Lite - A test providing means to calculate the possibility for existing ADHD.

These tests can swiftly confirm or reject suspected ADHD diagnosis in children and adults, providing a call-to-action or peace-of-mind on whether or not to seek a professional practitioner. The need for web-portal solutions for ADHD patients, their parents and caregivers is supported by findings from Ryan et al. [21] reporting that a vast majority of their test group, having used a website for educating on ADHD “would recommend a high quality website to others”. A case study on an online self-help application, called “cognitive behavior therapy for insomnia (CBTI)” by de Bruin et al. in 2014 [22], results pointed to improvements in sleep patterns within the test group consisting of adolescents. This study did not focus on ADHD patients exclusively, though insomnia being a common trait among ADHD patients, the paper argues that the findings are relevant for further investigation on ADHD patients. Results showed improvements in cognitive functioning, ability to maintain attention, working memory improvement, and to adequately be able to adapt to environment shifting.

A telemedicine-related study with ADHD patients as test group, was reported by Myers et al. [23] dating back to 2015. The study compared children receiving ‘telepsychiatry’ therapy whilst the other used a traditional consultation form. Results provided quantitative evidence promoting the efficacy of telemedicine technologies. Further, concerning effectiveness, the paper points to what cost-efficiency implications telemedicine technologies usage has as by reducing resources used for therapy sessions. This study provides valuable empirical data supporting that the quality of therapy is maintained or, according to Myers et al [23], arguably improved by implementing this form of consultation with healthcare professionals.

### 3.2. RQ2 - What is the contribution of eHealth technologies to ADHD patients?

Kemppinen et al. [24] lists common traits of adults with ADHD. According to Kemppinen, this can be expressed as: “An adult ADHD patient has continuously difficulties in organizing, prioritizing and getting things started. He or she has difficulties in focusing, sustaining and shifting attention”. The study reports on a clinical decision support system (CDSS) used in order to enhance the diagnosis process of people with ADHD. A central argument the study mentions, is the lack of diagnosis among adult people with ADHD, resulting in high risk of both substance abuse, crime, as well as comorbidities [24]. The CDSS system was implemented in a hospital in Finland back in 2012 in order to improve the access to a correct diagnosis. Results reported on improved workflow from an organizational point of view, a standardization of patient analysis and comprehensive reporting possibilities can be used to identify bottlenecks in the diagnosis process.

mHealth technologies are, according to Baum et al. [25], available and tailored for ADHD patients consisting of the following traits: improvement of organizational skills, push notifications for reminders, timers, reward charts, and tools to establish routines, stress reduction, and behavior tracking. On the other hand, the paper also claims the lack of evidence based support for the efficacy of such technologies, suggesting a need for further exploration. In the papers used in this review, there is a lack of empirical data supporting the quality of therapy improvement of mHealth technologies. Though the cost effectiveness can be justified, there is a need for evidence in addition to statements from parent and caregivers on such solutions.

### 3.3. RQ3 - To what extent does the vision of eHealth benefits serve people with ADHD?

By 2016, the global telemedicine market is expected to grow to nearly 27,3 billion dollars [26]. mHealth, a subset of telemedicine, aims to deliver healthcare anywhere and, according to Silva et al. [26], mHealth has strong impact on healthcare monitoring and drug-counterfeiting. Thereby the need for empirical studies on the impact on mHealth technologies in promoting improved mental health and cognitive functioning in patients with ADHD. The study includes “ADHD angel” in their list of mHealth aided technology solutions. In the applications description, included features are a reminder function for medication intake, and updates information on recent physician visits. The main argument for this application is the cost aspect. Further, it can be seen as a mend for the organizational issues that adults with ADHD in particular have.

One benefit of using EHRs was explored by Wu et al. [27] back in 2011. By using EHRs to assess comorbidities of patients with substance abuse disorders (SUDs), they found a prevalence of patients with ADHD patients (others were conduct disorder, oppositional-defiant disorder, mood disorder and anxiety disorder). According to the paper, 76 percent of American adolescents aged 14-18 years with current SUD have other psychiatric disorders listing ADHD as one of these. The study concludes that patients with SUDs require an extensive psychiatric assessment. The study bears evidence for a connection between mental disorders and substance abuse, giving implications for further research on testing people with SUDs using the DSM-V, hence improving the accessibility of correct diagnosis.

The use of EHRs can mitigate potential dangers associated with stimulant medication therapy in ADHD patients. A study from 2012 [28] shows the potential of reusing clinical health data. Given the legislative rights, EHR technology makes it possible to centralize data in order to aid decision-making, and reducing risk of fatal outcomes. The paper outlines cases from Canada and the United States reporting incidents of sudden death, heart attack and strokes in children under therapy of ADHD due to flaws in medication administration. The need for evidence-based recommendations for rare diseases causing such outcomes by using centralized EHRs, poses the question of what benefits can come from, given consent of governing bodies, attaining reuse of patient data and centralizing EHRs both on a domestic and international scale.

Baum et al. [25], uses ADHD as an example when outlining benefits of a health reform, referencing the HITECH act. The use of EHRs holds promise for the following metrics:

- Early identification - Mitigate the consequences of untreated disease.
- Symptom monitoring - Founding a basis for understanding the disease course and determine the effects of intervention.
- Patients registries - Identifying population level benchmarking and determine effects of intervention.
- Efficient, effective communication - Improved communication means during and between consultations.



- Improved access - Offering proper therapy when concerns are identified.
- Provider supports - Encourage practice change through the use of supports to change behavior.

The study mentions the need for access to data that can be used to determine current performance of therapy practices.

#### 4. Limitations

This study includes literature available from non-medical libraries entirely. The purpose of this is to provide a ICT POV, thus literature from libraries such as JMIR ([www.jmir.org](http://www.jmir.org)), and PubMed ([www.ncbi.nlm.nih.gov/pubmed](http://www.ncbi.nlm.nih.gov/pubmed)) are not represented. Another remark from the author is that the pattern of publication dates showed a clear increase of relevant literature since 2015. At the time of writing, 2016 allegedly holds an increased amount of research on eHealth technologies with an estimated increase of reported mHealth solutions by the end of this year.

#### 5. Conclusion

The development in eHealth technologies points to recent increase on focus on mHealth technologies. This has had an immense impact on ADHD patients. Authors present a systematic literature review on the main implications of eHealth for ADHD patients in this paper. By answering three different RQs, authors highlighted the most important and promising uses of eHealth in the field of ADHD therapy. The quality of therapy and efficacy are subjects for future work, including evidence-based research that can serve as support when suggesting new practices and therapy procedures. Most precisely, authors aim to study the intersection of serious games supported by technology and ADHD.

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